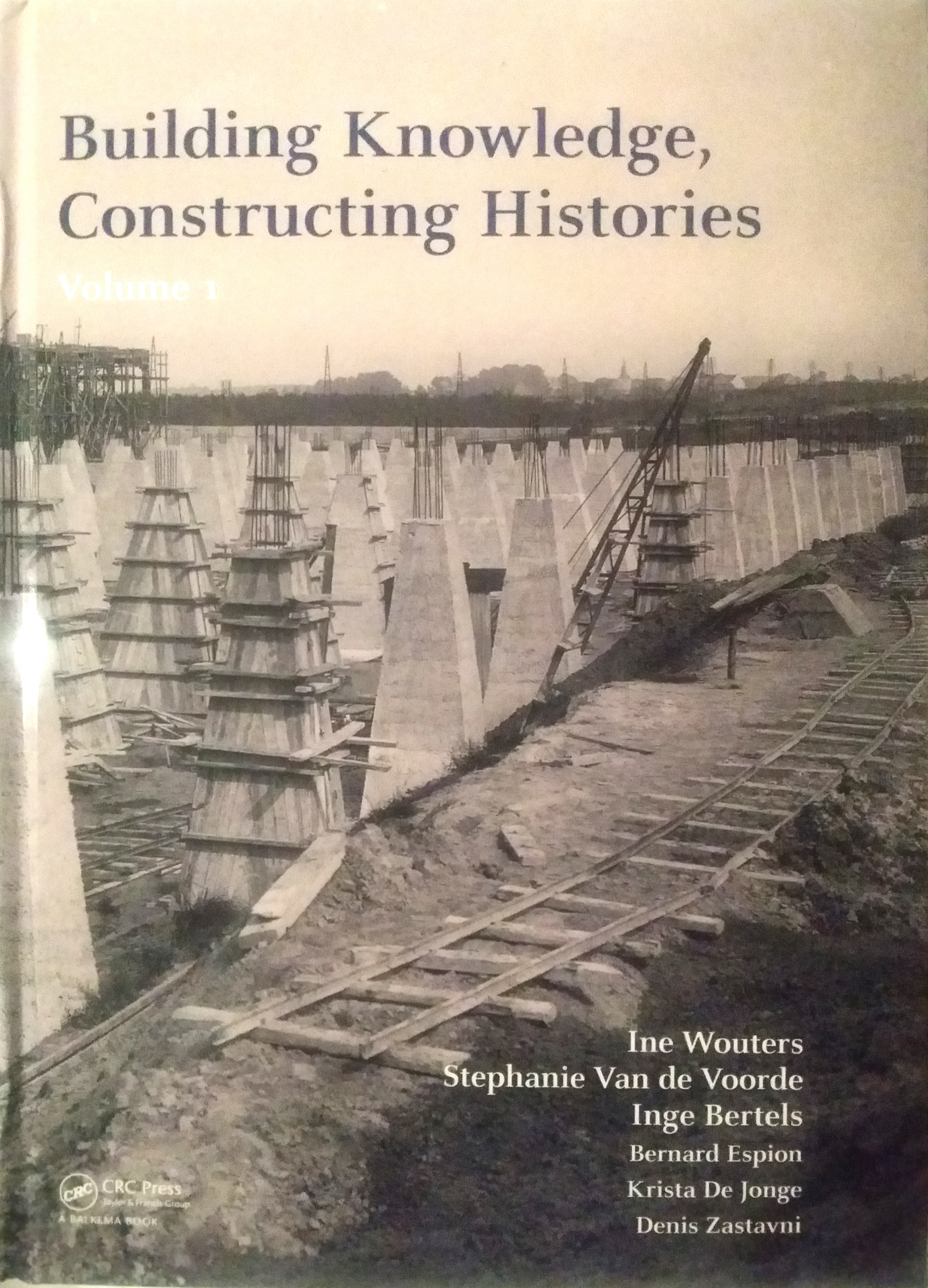
Building Knowledge, Constructing Histories

Volume 1



Ine Wouters
Stephanie Van de Voorde
Inge Bertels
Bernard Espion
Krista De Jonge
Denis Zastavni

CRC Press
Taylor & Francis Group
A BALKEMA BOOK

Building Knowledge, Constructing Histories – Wouters, Van de Voorde, Bertels et al. (Eds)
© 2018 6ICCH, Brussels, Belgium, ISBN 978-1-138-33230-0

Porto tower buildings in the 1960s: Challenges to architects and engineers

Rui Fernandes Póvoas & Clara Pimenta do Vale
University of Porto, Porto, Portugal

ABSTRACT: This paper analyses the design and construction of high-rise buildings, assessing the implications of this 'new' building type on design processes, either from an architectural point of view, as new organisational requirements were needed and new regulations had to be applied, or from an engineering point of view, as the increased height and their concentrated load required new structural approaches and calculation methods. The central analysis focuses on four early projects by four different architects and four engineering teams: the 14-storey Miradouro Building of *Cooperativa dos Pedreiros*, built in the eastern part of Porto; the 18-storey Hotel D. Henrique, in the city centre, just a few hundred meters from the City Hall; the 12-storey Montepio Geral Building and the 13-storey Social Security Building, both located near the Boavista Axis, in the western part of the city.

Keywords: 20th century, Portugal, Tall Buildings, Concrete Structures, Porto

1 INTRODUCTION

In an early-twentieth-century article that was published over several issues of an architecture and construction magazine ([S.N.] 1903, 220–221), skyscrapers were depicted as a great novelty coming from the United States. High-rise buildings were uncommon in Portugal at that time, in the capital Lisbon and even less so in the country's second city, Porto. In fact, housing developments were very different in these two cities. In Lisbon, housing constructed after the eighteenth-century earthquake was often for collective use, while in Porto most houses were privately owned, according to individual building schemes. Therefore, in Porto towers (meaning freestanding buildings with more than 10 storeys) were only built from the middle of the twentieth century onwards. These tower buildings responded to new demands, reflecting new developments in architecture, engineering, and construction.

The promotion and construction of towers is mostly concentrated in the 1960s and 1970s, with very few examples of a later date. Today still, these towers shape the Porto skyline alongside other historical edifices such as the baroque *"Torre dos Clérigos"* or the early-twentieth-century City Hall tower.

This study is part of an ongoing research analysing the design and construction of high-rise buildings and assessing the implications of this 'new' building type on design processes, either from an architectural point of view, as new organisational requirements were needed and new regulations applied, or from an engineering point of view, as the increased height and their concentrated load required new structural approaches and calculation methods. In a second phase, the final influence on the local Architecture, Engineering, and Construction (AEC) industry will be examined with respect to construction developments and innovative solutions adopted in those buildings.

The central analysis is focused on four early projects by four different architects and four engineering teams: the 14-storey Miradouro Building of *Cooperativa dos Pedreiros*, built in eastern Porto; the 18-storey Hotel D. Henrique, in the city centre, just a few hundred meters from the City Hall; the 12-storey Montepio Geral Building and the 13-storey Social Security Building, both located near the Boavista Axis, in the western part of the city.

2 THE EMERGENCE OF NEW BUILDING TYPES

The appearance of the first tower buildings in Porto is, in a way, the culmination of a process that occurred mainly in the 1950s and inter relates three aspects:

- the beginning of the systematic use of building types for collective housing, whether affordable housing (municipal or state-funded) or housing for middle-class tenants;

- the introduction of urban proposals based on the Athens Charter, with free standing blocks surrounded by open spaces, not aligned with the street;
- the 1955 horizontal property legislation (Portugal 1955–10–14) which was determinant for the increase in the size of the building developments, giving new tools to the emerging real estate sector (Vale & Almeida 2012).

Traditional building types in Porto in the eighteenth and nineteenth century were mainly based on long narrow lots, taking advantage of public space within city-walls (Fernandes 1999, Vale & Almeida 2012). As the city expanded outside those boundaries from the late eighteenth century onwards, the definition of the lot remained nearly the same, a reflection of a long-standing tradition but also stemming from restrictions in construction, as in the limitations on the span of timber beams (Teixeira 2004, Vale 2011, Teixeira & Póvoas 2012). Collective housing, conceived as a design requirement and not as a response to poverty and overcrowding, was very rare before the 1930s. The Aliados City Centre, built from 1916 onwards, is an early exception (Figueiredo, Vale & Tavares 2013, Vale 2017). Yet still in the 1930s collective housing including common spaces was not common in Porto. Interesting examples of early collective building projects, yet still without common spaces, are the 1930 *Inova Casas p'todos* ingeniously designed by architect João Queirós (Vale 2011, 319–21) and the four houses in Boavista designed by architect ArménioLosa (Vale 2011, 340–45) in 1936. In the first, the private entrance to the houses on the two floors, their basement and backyard areas was created by a set of individualized stairs. The second, which may look like a collective housing scheme, is in fact a group of four independent houses, three storeys high.

As for the promotion of affordable housing, it is only with the 1956 *Plano de Melhoramentos* [Improvement Plan] and the Decree-law nº40616 that collective housing models were systematically implemented in Porto. Previously, promotion and support for affordable housing was related to individual housing, freestanding or grouped in pairs, groups of four or in small rows. A unique example is the Saldanha collective building, with 115 dwellings, designed in 1937 by A. Magalhães and finished in 1940 (CMPorto 1966, 8). Serving almost as a pilot project is the Ramalde Neighborhood, designed in 1952 by architect Fernando Távora and inspired by some previous interventions in Lisbon.

From 1956 onwards, the Improvement Plan enabled the construction of several new neighbourhoods, intended to relocate poorly housed residents from overcrowded housing in the historic centre or workers' houses in nineteenth-century urban expansion zones, which were generally organised as traditional city blocks [called *ilhas* – islands]. All the new neighbourhoods, built in the late 1950s and 1960s, were based on collective housing schemes following the urban proposals from the Athens Charter. In terms of structure, they used a combination of masonry walls and concrete slabs, in continuity with construction systems from the first half of the twentieth century. In Porto, both in public and privately-owned buildings, the urban models from the Athens Charter only appeared in the 1950s.

A freestanding implantation is not a requirement for the construction of a tower building, as the Montepio Geral building and the Hotel D. Henrique building, both aligned to the street, prove. Not aligning it with the street does however ease the legal necessity to leave a vacant space equal to the building's height in front of all the façades as put forward by the 1951 *Regulamento Geral das Edificações Urbanas* – RGEU (Portugal 1951–08–07) [General Regulation of Urban Buildings]). In addition, it also allows to design the building as different parts around a central vertical circulation core.

The 1950s in Porto also constituted a turning point in the transition between traditional construction systems with masonry walls, and the 'new' construction systems using reinforced concrete frames and infill walls, which would become the standard until the end of the twentieth century. Pillars were first introduced in the 1920s, either exceptionally to solve specific issues, for example the stairwell area in the Carvalhosa building (Vale 2011) or systematically for the internal structure, as in the Monumental building (Vale 2017). Yet it was not until the 1950s that the reinforced concrete portico structure, combined with lightweight walls, became common.

In order to characterize this period, we must also mention the first National Congress of Architecture, held in 1948: encouraging a national debate on important issues related to the field of architect such as housing problems, social responsibility of architects, and rational construction, the congress strongly influenced the architectural practice of that time.

3 BUILDING IN THE SKY

In the late 1950s, the premises for the design and construction of the first tower buildings were present. These towers appeared as a natural consequence of the developments in the construction sector and the urban development of the city. Some

important architects of that period were involved in the construction of one or more tower buildings, which were seen as an opportunity to test modern architectural ideas and structural solutions. The building that paved the way for the construction of high-rise buildings in Porto was the Rialto located in Praça D. João I and designed by architect Rogério de Azevedo (1940–44). Nine storeys high, and thus not a proper tower according to the definition, it was nevertheless for a long time called the 'skyscraper' (Figueiredo, Vale & Tavares 2013, 158), being the tallest building in Portugal when it was built.

3.1 *Montepio Geral building (1960–62)*

The Montepio Geral building, begun in 1960, was the first tower to be designed by architect Agostinho Ricca and structural engineer César Máximo. Built at the corner of Rua de Júlio Dinis and Rua de São Paulo, it generally respects the urban indications defined in the Robert Auzelle plan (CMPorto & Ricca Gonçalves 1961, 3).

The building was commissioned by Montepio Geral, founded in 1840 as *Monte Pio dos Funcionários Públicos*, a private bank providing social protection for public employees based on reciprocity of services and mutual aid and as such a precursor of modern insurance companies. As real estate development is one of the resources to make profit from the capital invested, this bank owns several buildings in Porto, with special reference to their North Headquarters, located at Avenida dos Aliados (Figueiredo, Vale & Tavares 2013) and this one at Rua Júlio Dinis.

The construction company was António Fernandes da Silva & Irmãos, Lda, (also known as Empreiteiros Casais), a small company from Braga established in May 1958 that still exists today as an international group. The Montepio Building *"the highest building in Porto and the north of the country"* (comunicarte.pt 2008, 31) presented a great challenge for Casais, and it almost led to the firm's bankruptcy. The building's size and the fact that the construction coincided with Portuguese mass emigration to France causing wage rises, along with the beginning of the Colonial War in 1961, also increasing wages and material costs, made the situation very difficult for the company, which began to accumulate substantial losses and failed to make payments to suppliers. The situation was overcome in part via creditors' support and in the guarantees assured from partner equity and new work projects already taken on (comunicarte.pt 2008, 31–35).

The Montepio construction was certainly important for company's development of building techniques. The workers departed from Braga on Mondays in the early morning in a truck to Porto, where they would spend the week working on the building. Antonio Casais, the main partner of the building company, visited the building site frequently.

Figure 1. Montepio Geral Building in 1962 ([S.N.], 1962).

3.2 *Miradouro building (1962–69)*

The Miradouro Building (CMPorto, Martins & Silva 1964) was designed by architects David Moreira da Silva and Maria José Marques da Silva Martins and structural engineer Manuel Eduardo Coimbra. The building was part of a previous multifunctional complex owned by the *Cooperativa dos Pedreiros* – an organisation for stoneworkers, founded in 1914 by a group of workers who were building the São Bento Railway Station at the time. During the 1930s this *Cooperativa* built its headquarters inside a city block located near Rua da Alegria. It included a school for the workers and places to stay. In the 1960s the acquisition of the houses facing the street allowed for the construction of a new building, providing a permanent income to support retired workers and their families. As the lot was not big enough to ensure large investment profits from a low-rise building, a 'tower' was the obvious solution. This would also contribute to the urban landscape, as was noted in a request for prior information made to the city officials (Martins & Silva 1962). In the same document, justifying the choice for a tower, the Luso-Lima

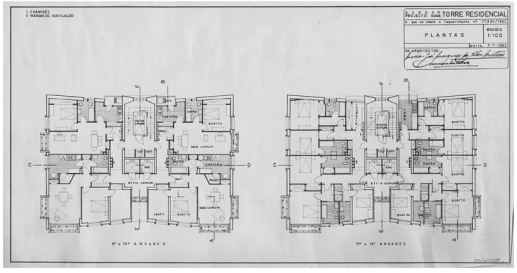


Figure 2. Miradouro Building plans, 9–10 floors—apartments and 11–12 floors—Inn (CMPorto et al., 1964).

towers, under construction at that time, were mentioned. The urban development of the Luso-Lima residential complex was designed by architect José Carlos Loureiro for the 'Misericórdia do Porto', and it integrated both medium-high rectangular buildings and two 10-storey tower buildings, containing two dwellings per floor (the urban plan is from 1960, building design and construction from 1961–68) (AA.VV. 2012, 76–83).

3.3 *Hotel D. Henrique (1965–73)*

The Hotel D. Henrique (CMPorto & Loureiro 1966), designed in 1965–73 by architects José CarlosLoureiro and Luís Pádua Ramos and structural engineers Amendoeira dos Santos and Aires Pereira, is part of a small complex with a shopping centre and several offices. The Hotel D. Henrique was the first large-scale hotel in Porto. Prior to this project the hotel 'Infante de Sagres', designed in 1943 by Rogério de Azevedo on the newly opened Praça Filipa de Lencastre, was the main reference. Being part of a complex with mostly seven storeys and a 70-meter long façade (of which the hotel occupies only a part), it is integrated into the surrounding urban fabric. Indeed, the Hotel D. Henrique is a noteworthy city landmark and has opened the way for other high-rise hotels from international brands (Meridien, Sheraton, Ipanema, etc.).

Loureiro had also designed the Luso-Lima towers. As the urban context and the program of the two buildings was different (housing versus commercial complex, hotel and restaurant), the architect came up with two distinctive designs. In case of the Luso-Lima towers, which are freestanding, the architect had also defined the urban plan, along with the building's shape (an irregular trapezoid) and orientation (important spaces facing south). In contrast, the Hotel D. Henrique occupied a large lot on the corner of a city block. The building was shaped and organized in such a way that, at the lowest levels, it relates to the urban public space and matches the neighbouring buildings.

The highest part of the building complex, the fan-shaped tower, was situated at the corner, across a municipal car park on the north side (Siloauto): this shape and location enhances the surrounding views, also evoking Aalto buildings.

The owner was SOGIN—Sociedade Gestora de Iniciativas Financeira, SA, a real estate group, also connected to the bank sector, still operating today. The construction company was Soares da Costa, for some time one of Portugal's largest construction companies, and responsible for the introduction of heavy prefabrication in the North of Portugal, with another tower building as its prefabrication kick-off project—the Boavista Condominium (Vale & Abrantes 2014, Vale 2016). Although finally not implemented in the Hotel D. Henrique, the use of precast panels in the façade is referred to in the detail drawings.

3.4 *Social security building (1968–70/78)*

The Social Security Building (CMPorto & Losa 1970) was designed in 1968 by architect Arménio Losa, with the structural engineering firm 'Engenheiros Reunidos'. It was initially conceived as a collective housing development and a profit-making scheme for a group of investors (mostly professionals, including the engineers responsible for designing the structure). The fact that António Soares was involved both as an engineer from 'Engenheiros Reunidos' and as an owner is interesting in the analyses of the chain of decisions, namely regarding the relationship between architecture and engineering.

The real estate development depended on the successful sale of the dwellings, but as this did not go to plan, other forms of funding had to be

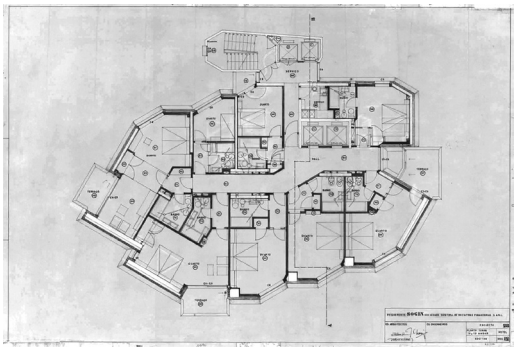


Figure 3. Hotel D. Henrique plan, 5–13 floors (CMPorto & Loureiro, 1966).

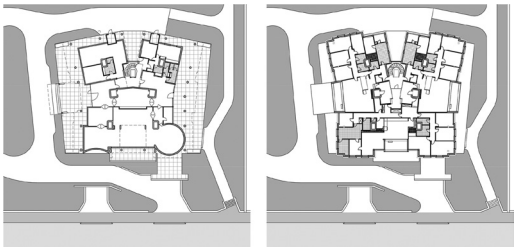


Figure 4. Social Security Building, Ground Floor and 1–12 floor (Vale 2011, 417).

found. Eventually, the unfinished 11-storey concrete structure was acquired by *Federação das Caixas de Previdência* [Social Security] in 1972 for their Porto headquarters. The same team that was responsible for the original project took charge of the adaptation of the built concrete structure to the new demands. The adaptation also included the construction of an adjacent building to hold four extra elevators and a new stairwell (Vale 2011, 415–73). In the present paper, the study focuses on the original project of collective housing, as the structural elements and calculations did not change.

4 MAIN IMPLICATIONS IN DESIGN AND CONSTRUCTION

Although these buildings are considered tower buildings, both by their designers and still today by Porto society, they have quite different dimensions and proportions (Fig. 5). The tallest and most slender is the Hotel D. Henrique, more than 60 m high, and is also the example in which the sense of verticality is magnified by the irregular shape of the plan. The other three have similar heights, yet their location within the city's topography lends them a very different presence in the Porto skyline.

A more detailed analysis of the four buildings, trying to assess the existence of interrelationships between a 'tower' as building type and particular design and construction options, allowed us to identify several aspects.

4.1 *Form and implantation*

The Miradouro and Social Security towers have a regular shape, closer to a square, locating all accesses in a central manner. In both cases, the stairs' natural lighting and ventilation are guaranteed (as indicated in the RGEU for buildings with more than three floors). The Montepio and Hotel D. Henrique towers have a rather irregular shape,

	High (meters)	**Dimensions** (meters)	**Slimness Coefficient**
	Main High	Major Axis	Major Axis
		Minor Axis	Minor Axis
	Additional high	*Average*	*Average*
Montepio Geral Building	36,60	29,85	0,82
		24,54	0,67
	6,30	*27,19*	*0,74*
Miradouro Building	43,75	23,40	0,53
		14,80	0,34
	1,80	*19,10*	*0,44*
Hotel D. Henrique	61,60	25,61	0,42
		19,67	0,32
	9,40	*22,64*	*0,37*
Social Security Building	42,90	33,90	0,79
		30,19	0,70
	4,90	*32,05*	*0,75*

Figure 5. Comparative table of the dimensions and proportions of the four buildings analysed.

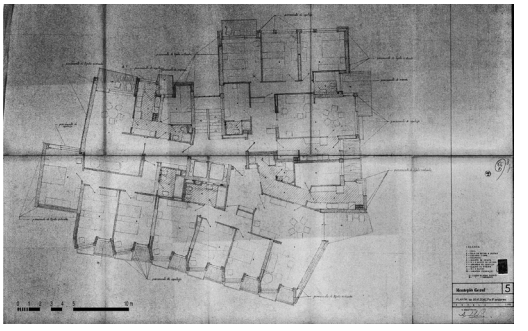


Figure 6. Montepio Geral building plan, 3–8 floor (CMPorto & Ricca Gonçalves 1961).

although with different approaches. Montepio uses the vertical communication core to articulate the two parts of the building, facing the two streets (Fig. 6), while the Hotel puts the nucleus of communications eccentrically, for a smaller interference in the spatial distribution of the floors.

4.2 *Floor layout*

The possibility of placing windows with all solar orientations, allowing more freedom in the dwellings' floorplan, was used differently by architects, also in relation to the program. In the Hotel, as the views and orientation are determinant, the shape of the building and the location of windows are a direct result of the orientation, and specific studies were made.

Despite the existence of a different layout on several floors, the locations of windows, balconies, and other determinant elements for façade composition is kept independent of those variations. Some rationalization of construction is granted by the replication of elements on several floors, and prefabrication began to be seen as a solution.

The way the vertical circulation was conceived also changed with the increase in height. The staircase began to be regarded as secondary access, giving priority to the use of elevators. As for dimensions of vertical circulation, the RGEU regulation stipulated increased width from three floors onwards (for the stairs) and more than four to five floors (for the elevators), this making them similar to lower buildings. It was not until 1975 that minimum widths were stipulated for the stairs of buildings over 30 m high (alteration to RGEU by Decree Law 650/75).

4.3 *Building services*

The increase in height also raised questions regarding the building services, namely the water supply. In the examples analysed, the height of the building implied that the pressure of the public water network alone could not ensure the supply of water to the highest floors. The common option was to place water tanks atop the building (over the elevator shaft) and then guarantee supply by gravity. The vertical organization also facilitated the placement of collective trash chutes.

4.4 *Structure*

From a structural point of view, the increase in height makes tower buildings more prone to horizontal actions resulting from wind and seismic activity, creating relatively new challenges in terms of structural design. At that time, seismic activity was however not taken into account in the structural design for buildings erected in the North of Portugal (Porto is in fact defined as a low seismicity zone). Consequently, wind was the only horizontal action to be taken into account in the design and structural calculations. How did the design teams respond to this problem?

The strategies showed some similarities, in spite of differences in the design, the historical context and, in relation to that, the legal framework. Indeed, in 1961 and in 1967, new regulations on the structures of buildings and bridges were established in Portugal, namely the *Regulamento de Solicitações em Edifícios e Pontes* – RSEP [Regulation on Actions of Buildings and Bridges] (Portugal 1961–11–18) and the *Regulamento de Estruturas de Betão Armado* – REBA [Regulation of Reinforced Concrete Structures] (Portugal 1967–05–20).

A first common characteristic is found in the use of a reinforced concrete core and/or walls as a bracing system. In the Montepio Geral building, a significant number of load-bearing walls is used to reduce any torsional effects. These walls are positioned in two roughly orthogonal directions, without any concerns regarding symmetry. The reinforced concrete beams and the lightweight floor slabs (25 cm thick, consisting of 5 cm wide ribs in reinforced ribs, spaced at 22 cm, and a compression layer of 5 cm) distribute the horizontal forces in the floors (Fig. 7).

In the Miradouro Building, the bracing functions are exclusively attributed to a central core, linked with the stairwell and elevators. This large core is positioned in the centre of the transverse axis, yet off centre in the longitudinal direction. Furthermore, the eccentricity is increased as the longitudinal façade closest to the core is the only one containing reinforced concrete walls. The structure is completed with columns, beams and lightweight slabs with 20 cm thick ceramic elements. Near the core, the slabs are solid to ease the transfer of the horizontal loads to the core (Fig. 8).

In the Hotel D. Henrique, with its irregular floor plan, the bracing is assured by a large number of reinforced concrete walls, arranged in the two main directions and located either inside the building or peripherally. Also in this case, reinforced concrete beams and lightweight floor slabs with ceramic elements are present (Fig. 9).

Finally, in the Social Security Building, and as shown in Figure 10, an approximately square and symmetric plan is adopted. It includes six cores in the central zone of the building and freestanding columns near the façades. It is also worth mentioning that it is one of the first buildings in Portugal to use waffle slabs. In accordance with the patented *'Ferca'* system, these 36 cm thick slabs had maximum spans of 7 m and 1.5 m cantilevers near the façades (Fig. 10).

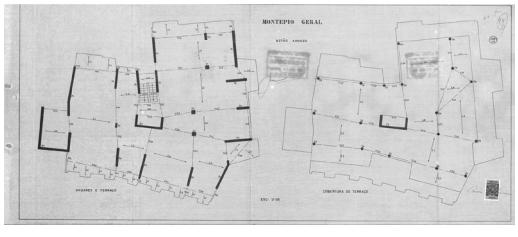


Figure 7. MontepioGeral building, structural schemes of floorplans, terrace and roof (CMPorto&Ricca Gonçalves 1961).

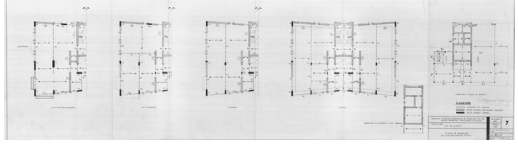


Figure 8. Miradouro Building: distribution plants of reinforced concrete elements (CMPorto et al., 1964).

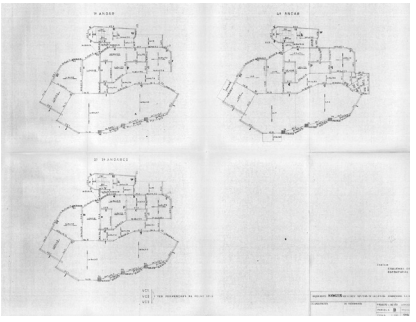


Figure 9. Hotel D. Henrique: structural schemes (CMPorto & Loureiro, 1966).

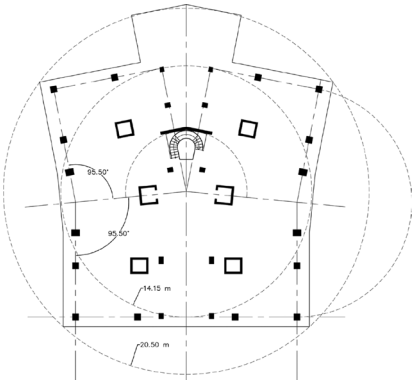


Figure 10. Social Security Building: structural schemes (Vale 2011, 421).

Regarding the calculation models adopted, the structural design of the cases did not differ substantially from one another, at least for the first three cases. They are based on simplified analysis models: the wind is the only horizontal load taken into account and reinforced concrete walls and core were considered as simple vertical consoles. In the Montepio Geral building, the *Regulamento de Segurança das Construções contra os Sismos* [Regulation on the Safety of Buildings against Earthquakes] (Portugal 1958–05–31) and the *Regulamento do Betão Armado* [Regulation of Reinforced Concrete] (Portugal 1935–10–16) were taken into account. In the Miradouro Building and the Hotel D. Henrique, the legal framework consisted of the aforementioned *Regulamento do Betão Armado*and the *Regulamento de Solicitações em Edifícios e Pontes* [Regulation on Actions of Buildings and Bridges] (Portugal 1961-11-18). As for the detailing of the structural elements, the solutions adopted were very common for that time, as shown in Figures 11–12.

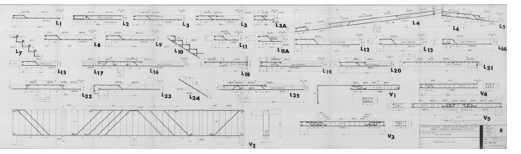


Figure 11. Miradouro Building: reinforced concrete elements (CMPorto et al., 1964).

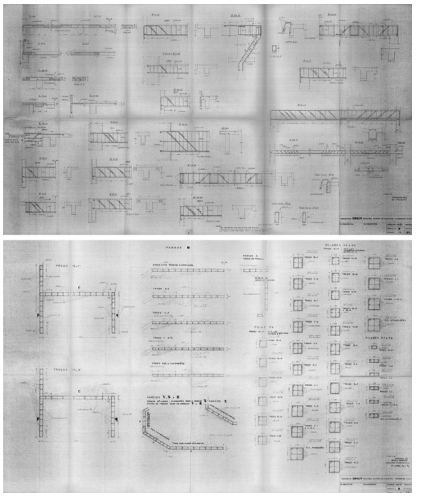


Figure 12. Hotel D. Henrique: reinforced concrete elements (CMPorto & Loureiro, 1966).

The Social Security Building is somewhat different: being the most recent, it was already covered by the new Regulation on Reinforced Concrete Structures—REBA (Portugal 1967–05–20) and the aforementioned Regulation on Actions of Buildings and Bridges—RSEP (Portugal 1961–11–18). Although the building is located in a region which is considered to be of low seismic risk and thus not legally necessary to follow the RSEP regulation, the analysis is more sophisticated and included seismic stability. Two different models to analyse horizontal wind loads and earthquake action were considered: a simplified one, which, in line with previous projects, considered only the contribution of the six core bracing elements; and another, using an automatic calculation program, which took into account the connections and continuity of the reinforced concrete walls, columns and slabs. It should be noted that, at the time, this computerized calculation implied sending all the data to the National Civil Engineering Laboratory in Lisbon for further processing, as this was the only place in Portugal which provided access to this type of advanced calculation tools. Finally, with regard to the calculation of waffle slabs for vertical

loads, the provisions of the English Regulation CP114, as well as the provisions of the American Regulation ACI 318–63 were adopted.

5 CONCLUSION

As expected, the implications of an increase in the height of the buildings were more to be found at the structural level than at the architectural and construction level. In a low seismicity zone such as Porto, wind resistance was the issue that raised the most questions, and most designers preferred simplified calculations.

Future work will continue the analysis of a set of tower buildings already identified, crossing the structural calculation with the evaluation of the architectural design.

ACKNOWLEDGMENTS

This research is co-financed by the European Regional Development Fund (ERDF) through the COMPETE 2020 – Operational Programme Competitiveness and Internationalization (POCI) and by national funds via the FCT under the POCI-01-0145-FEDER-007744 project.

REFERENCES

[S.N.]. 1903. "As construções das 'cardas das nuvens' na América do Norte (I)." *A Construção Moderna* (112–1 de Novembro): 220–21.

[S.N.]. Edifício Montepio Geral, Rua Júlio Dinis. 1962. Cota: F-NP/CMP/4/2093, AHMP, Porto.

CMPorto. 1966. *Plano de melhoramentos 1956–1966.* Porto: Câmara Municipal do Porto.

CMPorto and Arménio Losa. Licença nº 86/1970, Rua António Patrício, 240 a 270 [Segurança Social]. 1970. CMP-AG, Porto.

CMPorto and José Carlos Loureiro. Licença nº 542/1966, Rua Guedes de Azevedo com a Rua do Bolhão [Hotel D. Henrique].1966. CMP-AG / FIMS, Porto.

CMPorto, Maria José Marques da Silva Martins and David Moreira da Silva. Licença nº 67/1964, Rua da Alegria, nº 574/594 [Cooperativa dos Pedreiros]. 1964. CMP-AG / FIMS, Porto.

CMPorto and Agostinho Ricca Gonçalves. Licença nº 504/1961, Rua de Júlio Dinis 648–656 [Edifício Montepio Geral]. 1961. CMP-AG, Porto.

Comunicarte.pt. 2008. *Mestria*. Braga: Empreiteiros Casais, de António Fernandes da Silva, S.A.

Fernandes, Francisco Barata. 1999. Transformação e Permanência na Habitação Portuense. As formas da casa na forma da cidade. Porto: FAUP publicações.

Figueiredo, Ricardo, Clara Pimenta do Vale and Rui Tavares. 2013. *Aliados Avenue and Centre of Porto: Memory, Reality and Permanence.* Porto: Porto Vivo SRU.

Martins, Maria José Marques da Silva and David Moreira da Silva. Requerimento registado sob o nº 17690. 1962. FIMS: 1988/4189, Porto.

Portugal. 1935–10–16. Decreto n.º 25948: Regulamento do Betão Armado. Ministério das Obras Públicas e Comunicações. Lisboa: Diário do Govêrno n.º 240/1935, Série I.

Portugal. 1951–08–07. Regulamento Geral das Edificações Urbanas [RGEU]. Lisboa: Diário do Governo nº 166/1951.

Portugal. 1955–10–14. Decreto-Lei nº 40 333: Propriedade horizontal. Ministério da Justiça. Lisboa: Diário do Governo n.º 223/1955.

Portugal. 1958–05–31. Decreto n.º 41658: Regulamento de Segurança das Construções contra os Sismos. Ministério das Obras Públicas. Lisboa: Diário do Governo n.º 117/1958, Série I.

Portugal. 1961–11–18. Decreto n.º 44041: Regulamento de Solicitações em Edifícios e Pontes. Ministério das Obras Públicas. Lisboa: Diário do Governo n.º 268/1961, Série I.

Portugal. 1967–05–20. Decreto n.º 47723: Regulamento de Estruturas de Betão Armado. Ministério das Obras Públicas. Lisboa: Diário do Governo n.º 119/1967, 1º Suplemento, Série I.

Teixeira, Joaquim José Lopes. 2004. "Descrição do sistema construtivo da casa burguesa do Porto entre os séculos XVII e XIX. Contributo para uma história da construção arquitectónica em Portugal." Provas de aptidão pedagógica e capacidade científica, Faculdade de Arquitectura da Universidade do Porto.

Teixeira, Joaquim and Rui Fernandes Póvoas. 2012. "Caracterização da Construção Tradicional do Norte de Portugal." In *Manual de Apoio ao Projecto de Reabilitação de Edifícios Antigos*, edited by Vasco Peixoto de Freitas. 33–61. Porto: Ordem dos Engenheiros Região Norte.

Vale, Clara P. and Vítor Abrantes. 2014. "An earlier example of Portuguese concrete prefabrication, the 'Torre da Boavista' condominium in Porto." *Sustainable Housing Construction – 40th IAHS*, Funchal, 16–19 December.

Vale, Clara Pimenta do. 2011. "Um alinhamento urbano na construção edificada do Porto. O eixo da Boavista (1927–1999). Contributo para a História da Construção em Portugal no século XX" PhD Thesis, Faculdade de Arquitectura da U. do Porto.

Vale, Clara Pimenta do. 2016. "The 'birth' of concrete prefabrication in Portugal: Pioneer examples in Lisbon and Porto." *43rd ICOHTEC meeting*, Porto, 26–30 July.

Vale, Clara Pimenta do. 2017. "Lo proceso de construcción del centro cívico de Porto en el período entre guerras: la introducción de nuevos materiales, sistemas constructivos y vocabularios arquitectónicos." *Décimo Congreso Nacional y Segundo Congreso Internacional Hispanoamericano de Historia de la Construcción*, San Sebastian, 3–7 October.

Vale, Clara Pimenta do and Vitor Abrantes Almeida. 2012. "Urban Dynamics and Horizontal Property: Case Study of the Boavista Axis, Porto, Portugal." Nuts & Bolts of Construction History, Paris, 3–7 July.